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Discovery and study of the accreting pulsar 2RXP J130159.6-635806

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ABSTRACT

We report on analysis of the poorly studied source 2RXP J130159.6-635806 at different epochs with *ASCA*, *BeppoSAX*, *XMM–Newton* and *INTEGRAL*. The source shows coherent X-ray pulsations at a period ~700 s with an average spin-up rate of about $\dot{\nu} \sim 2\times10^{-13}$ Hz s^{-1}. A broad-band (1–60 keV) spectral analysis of 2RXP J130159.6-635806 based on almost simultaneous *XMM–Newton* and *INTEGRAL* data demonstrates that the source has a spectrum typical of an accretion-powered X-ray pulsar, i.e. an absorbed power law with a high-energy cut-off with a photon index $\Gamma \sim 0.5$–1.0 and a cut-off energy of ~25 keV. The long-term behaviour of the source, its spectral and timing properties, tend to indicate a high-mass X-ray binary with a Be companion. We also report on the identification of the likely infrared counterpart to 2RXP J130159.6-635806. The interstellar reddening does not allow us to strongly constrain the spectral type of the counterpart. The latter is, however, consistent with a Be star, the kind of which is often observed in accretion-powered X-ray pulsars.

Key words: pulsars: individual: 2RXP J130159.6-635806 – gamma-rays: observations – X-rays: binaries – X-rays: individual: 2RXP J130159.6-635806.

1 INTRODUCTION

On 2004 February 7, during a routine Galactic plane scan, the *INTEGRAL* observatory detected a source which was not in the *INTEGRAL* reference catalogue. A search of the archive led to the identification of several *ROSAT* sources in the *INTEGRAL* error box. Among them 2RXP J130159.6-635806 is the closest one to the best estimate of the source position obtained with *INTEGRAL* (Chernyakova et al. 2004). The only mention of this source in the literature before the observations reported here (besides the *ROSAT* catalogue) can be found in Kaspi et al. (1995). In this paper the authors report results of *ASCA* observations of the famous binary system PSR B1259-63, and mention the presence of the another source located only 10 arcmin away to the north-west. Kaspi et al. (1995) note, in particular, that the absorption column $N_{\rm H}$ in the direction of this source is higher than that of PSR B1259-63, and that during their observations the brightness of 2RXP J130159.6-635806 was smaller, but comparable to that of PSR B1259-63.

We started to follow the source after its detection with *INTEGRAL* and our first *XMM–Newton* observation in a set of observations organized to monitor PSR B1259-63 during its 2004 periastron passage (PSR B1259-63 has a very long, 3.4 yr, orbital period). Analysing these observations we have noticed that 2RXP J130159.6-635806, which was also in the field of view, was significantly brighter than it was during the *ASCA* observations (Chernyakova et al. 2004).[1] On 2004 January 24 the 1–10 keV intensity was found to be approximately an order of magnitude higher than during the *ASCA* observation performed on 1995 August 13.

In 2001–2004 PSR B1259-63 was regularly monitored by *XMM–Newton* and 2RXP J130159.6-635806 was always in the *XMM–Newton* field of view. In this paper we present the analysis of all available X-ray data from *ASCA*, *BeppoSAX*, *INTEGRAL* and *XMM–Newton* in order to understand the nature of this variable source and to investigate its properties. In particular, using the *XMM–Newton* data we refine and improve the X-ray position, and discover X-ray pulsations. We study the long-term spectral evolution, and through a simultaneous fit to the *XMM–Newton* and *INTEGRAL* data, show that the hard X-ray source seen in *INTEGRAL* and 2RXP J130159.6-635806 are very likely to be the same object.

The paper is organized as follows. In Section 2 we present the sequences of observations and methods used for data reduction and

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[1] In Chernyakova et al. (2004) by a misprint the 1RXP catalogue was mentioned instead of the 2RXP one.

Table 1. Journal of the *INTEGRAL* observations of 2RXP J130159.6-635806.

Data set	Date	MJD	Exposure (ks)	20–60 keV flux (10^{-11} erg s^{-1} cm^{-2})
I1	2003-05-29–2003-07-18	52788–52838	260	1.4 ± 0.4
I2	2004-01-17	53021	5.3	3.83 ± 2.39
I3	2004-01-26	53030	6.1	12.86 ± 2.83
I4	2004-02-07	53042	4.2	15.04 ± 2.83
I5	2004-02-19	53054	4.0	6.42 ± 3.10

Table 2. Journal of *ASCA BeppoSAX* and *XMM–Newton* observations of 2RXP J130159.6-635806.

Data set	Date	MJD	Exposure (ks)
ASCA			
A1	1993-12-28	49349.28	20.7
A2	1994-01-26	49378.79	18.2
A3	1994-02-28	49411.61	8.3
A4	1995-02-07	49756.08	17.5
A5	1995-08-13	49942.98	19.6
BeppoSAX			
S1	1997-09-08	50699.44	84
XMM–Newton			
X1	2001-01-12	51921.73	11.3
X2	2001-07-11	52101.31	11.6
X3	2002-07-11	52467.24	41.0
X4	2003-01-29	52668.27	11.0
X5	2003-07-17	52837.53	11.0
X6	2004-01-24	53028.79	9.7
X7	2004-02-10	53045.43	5.2
X8	2004-02-16	53051.39	7.7
X9	2004-02-18	53052.02	5.2
X10	2004-02-20	53055.82	6.9

analysis. In Section 3 we present the results obtained, and discuss them in Section 4. We then give a summary of our analysis in the last part of the paper.

2 OBSERVATIONS AND DATA ANALYSIS

2.1 *INTEGRAL* observations

Since the launch of *INTEGRAL* (Winkler et al. 2003) on 2002 October 17, 2RXP J130159.6-635806 was in the field of view of the main instruments several times during the routine Galactic plane scans and pointed observations (see Table 1 for details). Most of the times the distance of the source from the centre of the field of view was too great and the exposure too short to use either the X-ray monitor JEM-X or the spectrometer SPI. Therefore, IBIS/ISGRI (Lebrun et al. 2003) is the only instrument we can use in our analysis of this source. In this analysis we have used version 4.2 of the Offline Science Analysis (OSA) software distributed by ISDC (Courvoisier et al. 2003).

In 2003 the source was only marginally detected with IBIS/ISGRI, while at the beginning of 2004 it was clearly seen in the 20–60 keV energy range. To obtain better results for spectral analysis we have combined data obtained on January 26 and February 7, when the source was brightest.

2.2 *XMM–Newton* observations

In the course of monitoring PSR B1259-63, *XMM–Newton* observed 2RXP J130159.6-635806 10 times during 2001–2004 (see Table 2 for the journal of observations). These data are a combination of public and private observations. The Observation Data Files (ODFs) were obtained from the on-line Science Archive,[2] and were then processed and filtered using XMMSELECT within the Science Analysis Software (SAS) v6.0.1. In all the observations the source was observed with MOS1 and MOS2 detectors only. The 2001–2003 observations (X1–X5) were performed in full-frame mode, while the 2004 observations were performed in small-window mode, in order to minimize pile-up problems for the primary source PSR B1259-63. In all observations a medium filter was used.

The spectra and light curves were extracted from a 35-arcsec radius circle around the source position for the weak state of the source (i.e. observations X1–X5, X9 and X10), and from a 50-arcsec radius circle for the outburst phase (observations X6–X8). As 2RXP J130159.6-635806 was not a primary goal of the *XMM–Newton* observations its position is shifted to the edge of the field of view, and the shape of the source is slightly elongated. Therefore, in order to avoid mixing of source and background photons for the weak states of the source, we collected background light curves and spectra from a 35-arcsec radius circle located close to the source. For the bright state of the source we have used a circle of larger radius, and collected background light curves and spectra from a 100-arcsec outer radius annulus centred on the source position.

Observations X2, X4, X6 and X9 were partially affected by soft proton flares. As proton flares originate from the interaction of the soft protons in the Earth's magnetosphere with the telescope, their timing behaviour is assumed to have no periodic structure. Therefore, no filtering of the data was applied to the timing analysis, as was done for another new X-ray pulsar IGR/AX J16320-4752 (Lutovinov et al. 2005a). We have nevertheless eliminated observations X4 and X9 from our study as in these data sets the influence of the soft proton flares was especially strong. The arrival times of the photons have been corrected to the Solar system barycentre. The pulse period was searched with the epoch folding technique (Leahy et al. 1983): we produced periodograms and derived the best-fitting period for each data set. 10 bins per trial period were used. For the determination of the uncertainty of the source period we used the bootstrap method. We simulated a number of source 'fictional' light curves, generating randomly (in accordance with the Poissonian statistics of the counts) its flux in each light-curve bin. These light curves provided us with the range of 'best-fitting' periods of the source pulsations, therefore giving us information concerning the period uncertainty. Errors given in the paper represent a 1σ confidence level.

For the spectral analysis the periods of soft protons need to be filtered out. To exclude them we extracted light curves above 10 keV with a 100-s binning and excluded all time bins in which the count was higher than 1.5 count s^{-1}.

Data from MOS1 and MOS2 detectors were combined in both timing and spectral analysis in order to achieve better statistics.

2.3 *ASCA* observations

2RXP J130159.6-635806 was in the *ASCA* field of view during the dates listed in Table 2. In our subsequent analysis we have

[2] http://xmm.vilspa.esa.es/external/xmm_data_acc/xsa/index.shtml

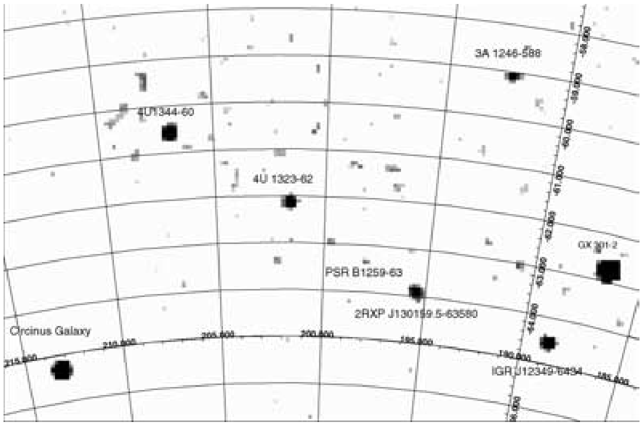

Figure 1. 20–60 keV significance mosaic of I1–I5 observations. The axes are in Equatorial J2000 coordinates (degrees).

used the data of both Gas Imaging Spectrometers (GIS 2 and 3). The data were analysed with the help of the standard tasks of the LHEASOFT/FTOOLS 5.2 package in accordance with the recommendations of the *ASCA* Guest Observer Facility.

2.4 *BeppoSAX* observations

During 1997 2RXP J130159.6-635806 was within the field of view of the instruments of the *BeppoSAX* observatory several times. Unfortunately, the flux from the source detected by the MECS telescopes was strongly contaminated by instrumental features (e.g. 'strongback', see Boella et al. 1997), and therefore a detailed analysis of the source spectrum is not possible. However, the data obtained can still be used for timing analysis. For the data reduction we used standard tasks of the LHEASOFT/FTOOLS 5.2 package. We only present here the results of an observation performed on 1997 September 8, when the statistics was good enough to perform a pulse search.

3 RESULTS

3.1 Imaging analysis

In Fig. 1 a zoom of the mosaic of all the *INTEGRAL* observations mentioned in Table 1 is given. 2RXP J130159.6-635806 is clearly seen in the image, along with a new source IGR J12349-6434 we have found during our analysis (Chernyakova et al. 2005a). All sources shown in the image were taken into account for a proper analysis of *INTEGRAL* data (Goldwurm et al. 2003).

During the *XMM–Newton* monitoring programme of PSR B1259-63, two sources were clearly detected (e.g. Fig. 2 represents the contour plot of observation X6). Besides PSR B1259-63 itself a second source can clearly be seen. The best coordinates we derive are RA(J2000) $= 13^{\rm h}\,01^{\rm m}\,58\overset{\rm s}{.}8$, Dec. (J2000) $= -63^\circ\,58'\,10''$ (the conservative error estimate is 3 arcsec). This position is about 6 arcsec from the best *ROSAT* position of 2RXP J130159.6-635806. The uncertainty of the localization of 2RXP J130159.6-635806 with *ROSAT* is 5 arcsec (ROSPSPC catalogue),[3] therefore we conclude that the most likely *XMM–Newton* source and the *ROSAT* one are the same.

[3] ftp://ftp.xray.mpe.mpg.de/rosat/catalogues/2rxp/pub

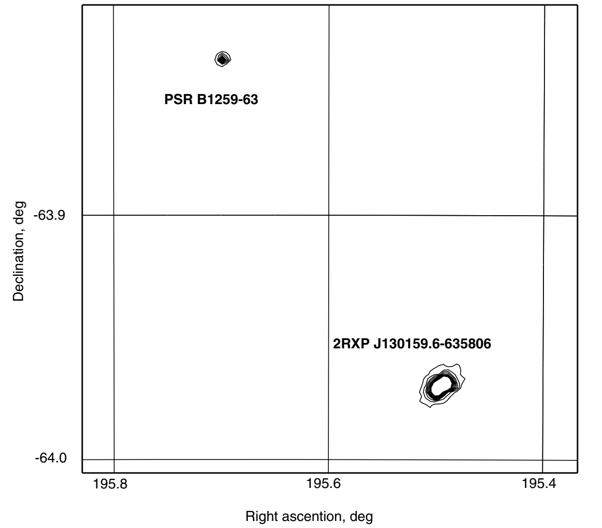

Figure 2. Contour plot of the *XMM–Newton* field of view for the X6 observation. A total of 10 contours were used with a linear scale. The external contour corresponds to 5 count pixel^{-1}, and the most internal one to 50 count pixel^{-1}. In this observation 2RXP J130159.6-635806 was 40 times brighter than PSR B1259-63.

3.2 Spectral analysis

The 1993–2004 time history of the 2–10 keV flux from 2RXP J130159.6-635806 as observed by *ASCA* and *XMM–Newton* is shown in the upper panel of Fig. 3. While during the *ASCA* and the first half of the *XMM–Newton* observations (X1–X5) the flux of the source was practically constant at a value of $\sim 2.5 \times 10^{-11}$ erg cm^2 s^{-1}, an outburst can be seen between the end of January and the beginning of 2004 February (observations X5–X10). During this period the source flux increased by a factor of more than 5. As a result of the strategy chosen for the PSR B1259-63 monitoring campaign, the whole outburst was not entirely covered. During the flare 2RXP J130159.6-635806 was observed only twice (January 24 and February 10), with approximately the same flux level. During

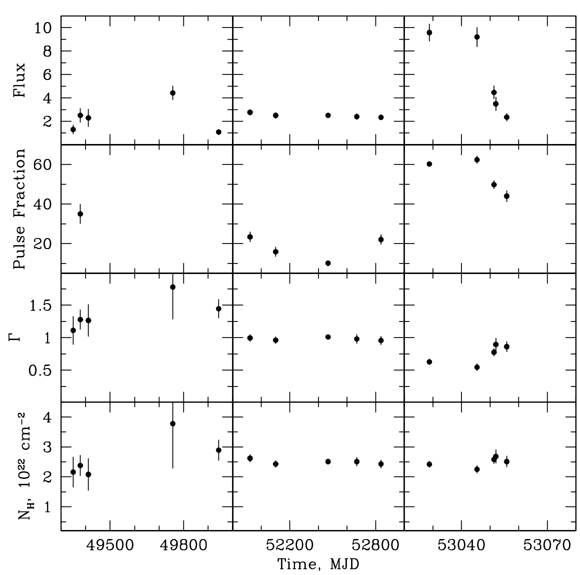

Figure 3. Time evolution of the spectral parameters of 2RXP J130159.6-635806 and the 2–10 keV pulse fraction (in per cent). The flux is given in units of 10^{-11} erg s^{-1} cm^{-2}.

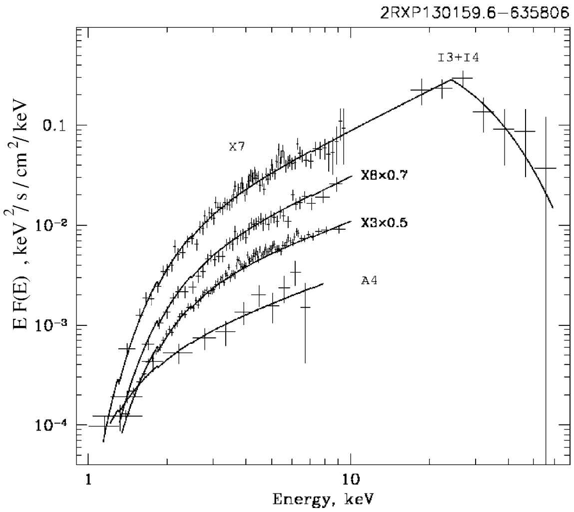

Figure 4. Spectral evolution of 2RXP J130159.6-635806, as observed with *XMM–Newton*, *ASCA* and *INTEGRAL*. To better show the spectral evolution for the *XMM–Newton* observations the spectra from observations X3 and X8 were multiplied by 0.5 and 0.7, respectively. The combined *XMM–Newton* and *INTEGRAL* spectrum is fitted with an absorbed power-law model with a high-energy cut-off.

the following 10 d its flux dropped to the 2001–2003 level with a characteristic decay time of ∼7.5 d (Fig. 3).

As can be seen from Table 1, this outburst was also detected by *INTEGRAL* in the 20–60 keV energy range. While in 2003 out of a ∼260 ks observation, the source was only marginally detected at ∼3σ level, it was clearly seen during a 6.1-ks observation on 2004 January 26 (I3), and during a 4.2-ks observation on 2004 February 7 (I4). At those times it was 10 times brighter than its averaged level over 2003. On 2004 February 19 (I5) and during a ToO observation of PSR B1259-63 performed in 2004 March (Shaw et al. 2004), the source was again only marginally or not detected.

The spectral analysis was performed using the XSPEC software package. The spectrum of 2RXP J130159.6-635806 during the lowest state as observed with *ASCA* in 1994 (observation A4), a typical *XMM–Newton* spectrum of the source in 2002–2003 (observation X3), *XMM–Newton* and *INTEGRAL* spectra during the outburst (observations X7 and I3+I4) and just after (observation X8), are shown on Fig. 4.

The *XMM–Newton* and *ASCA* data show that the spectrum of the source in the soft 2–10 keV energy range is well described by a simple power law modified by absorption. In Table 3 we present results of three-parameter fits. The uncertainties are given at the 1σ statistical level and do not include systematic uncertainties. A graphical representation of the evolution of the spectral parameters is shown in Fig. 3.

For all observations, the value of the photoabsorption is practically constant with an average value of $N_{\rm H} = (2.48 \pm 0.07) \times 10^{22}$ cm^{-2}. This value is about five times higher than the value we found for PSR B1259-63 ($0.48 \pm 0.03 \times 10^{22}$ cm^{-2}), which is located only 10 arcmin away (Chernyakova et al. 2005b). Measurements of the interstellar hydrogen in the Galaxy by Dickey & Lockman (1990) give $N_{\rm H}$ values in the range $(1.7 - 1.9) \times 10^{22}$ cm^{-2}, which is smaller than the one we deduced from X-ray spectral fits. This indicates that part of the absorption might be intrinsic to the source.

While the *ASCA* and *XMM–Newton* data are well fitted with a simple power law modified by photoabsorption (see Table 3),

Table 3. 2RXP J130159.6-635806 pulse period, as observed with *ASCA*, *BeppoSAX* and *XMM–Newton*. Observations X4 and X9 have been excluded, as they were strongly affected by soft proton flares.

Data set	Date MJD	Pulse period (s)	Pulse fraction (per cent)
A2	49378.79	735 ± 2.7	35 ± 6
S1	50699.5	730 ± 1.5	26 ± 5
X1	51921.73	721.9 ± 2.7	23.4 ± 2.6
X2	52101.31	716.8 ± 1.4	15.9 ± 2.4
X3	52467.24	714.4 ± 0.5	10.1 ± 1.3
X5	52837.53	704.0 ± 1.7	22.1 ± 2.5
X6	53028.79	703.8 ± 0.4	60.2 ± 1.2
X7	53045.43	703.7 ± 0.9	62.3 ± 1.9
X8	53051.39	703.9 ± 1.1	49.8 ± 2.2
X10	53055.82	704.2 ± 1.1	44.0 ± 2.9

INTEGRAL data show a presence of a high-energy cut-off at about ∼25 keV, which is typical for accreting X-ray pulsars (White, Swank & Holt 1983). We fitted the joint spectrum obtained with *XMM–Newton* (X7) and *INTEGRAL* (I3+I4) with an absorbed cut-off power law. The best-fitting parameters obtained are: $N_{\rm H} = (2.55 \pm 0.13) \times 10^{22}$ cm^{-2}, $\Gamma = 0.69 \pm 0.05$, $E_{\rm cut} = 24.3 \pm 3.4$ keV, $E_f = 8.5 \pm 3.3$ keV. The normalization of the *INTEGRAL/IBIS* spectrum was taken as arbitrary.

3.3 Timing analysis

Analysing the light curve of 2RXP J130159.6-635806 obtained with *XMM–Newton* in the bright state we find that it demonstrates near coherent strong variations with a characteristic time of about 700 s. Fig. 5 (upper panel) shows the example of a 48 s binned 2–10 keV MOS1 background-subtracted light curve of 2RXP J130159.6-635806 during the flare (observation X6). The periodograms (χ^2 distribution versus trial period for observations X3 and X6) are also represented in the same figure. Periodic variations

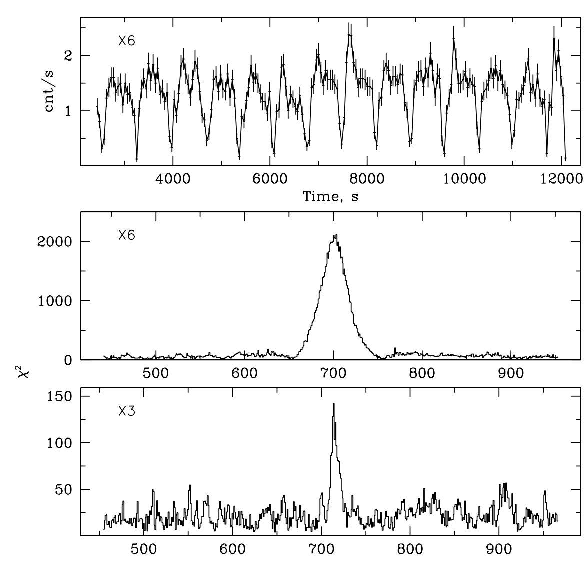

Figure 5. MOS1 2–10 keV light curve of 2RXP J130159.6-635806 during the flare (observation X6) (top panel) and the χ^2 distribution versus the trial period for the brightest (X6) and the longest (X3) observations (middle and bottom panels, respectively).

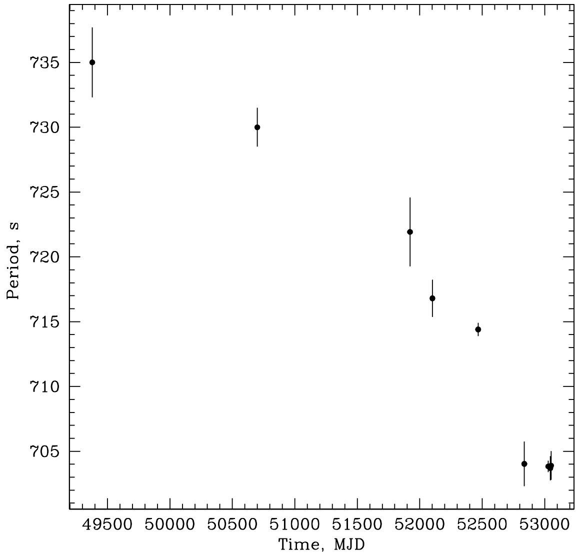

Figure 6. Time evolution of the 2RXP J130159.6-635806 pulse period.

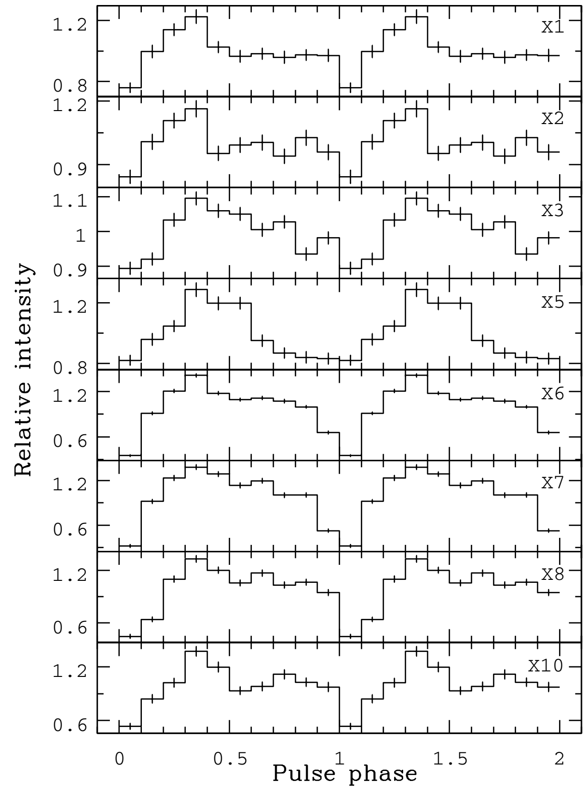

Figure 7. 2RXP J130159.6-635806 pulse profiles variations in the 2–10 keV energy range. Pulse profiles have been aligned using the minimum phase bin.

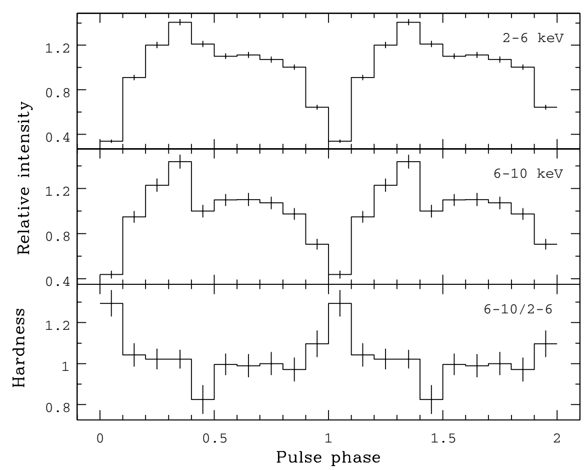

Figure 8. 2–6 and 6–10 keV pulse profiles of 2RXP J130159.6-635806 during the brightest observation (X6) along with the hardness ratio.

of the source flux are obvious. The following analysis showed that such variations are also observed in the light curve of the source in the low state.

Subsequent analysis of *ASCA* and *BeppoSAX* light curves of the source flux also showed pulsations, although not in all the data sets. This is due to the much smaller statistics of these data. With *INTEGRAL* data we can set only an upper limit on the pulse fraction. For the brightest I3 and I4 observations the 3σ upper limit is 70 per cent, which is consistent with almost simultaneous *XMM–Newton* observations, X6 and X7.

The values of the pulse period obtained between 1994 and 2004 are given in Table 3 and Fig. 6. The average spin-up rate changes from $\dot{P} \simeq -6 \times 10^{-8}$s s^{-1} in 1994–2001, to approximately $\dot{P} \simeq -2 \times 10^{-7}$s s^{-1} in 2001–2004, which corresponds to $\dot{\nu} \simeq 10^{-13}$ and $\simeq 4 \times 10^{-13}$ Hz s^{-1}, respectively.

The 2–10 keV pulse profiles of 2RXP J130159.6-635806 obtained in each data set by folding of the *XMM–Newton* light curves at the best-fitted period are shown in Fig. 7. In general, the source pulse profile consists of one broad peak, but in several observations (the low-intensity ones) some additional features (as a second peak) are visible. We have calculated the 2–10 keV pulse fraction $P = (I_{\max} - I_{\min})/(I_{\max} + I_{\min})$ (where $I_{\max}$ and $I_{\min}$ are intensities at the maximum and minimum of the pulse profile) in all the *XMM–Newton* observations. These values are plotted in Fig. 3 (second panel from the top). It is interesting to note that the pulse fraction is not constant and varies with time from ~10–25 per cent to ~60 per cent during the outburst.

Fig. 8 shows 2–6 and 6–10 keV pulse profiles of 2RXP J130159.6-635806 during the brightest observation (observation X6) along with the hardness ratio. We can see that the hardness ratio remains practically constant during the pulse, except just before phase 0.5, where it suddenly drops by ~20 per cent, and near the pulse minimum (around phase 1), where it increases by ~20 per cent.

In order to study the reasons for the variations in the shape of the pulse profile, we extracted separately spectra of observation X6 from the low phase and from the high phase. The background spectra were extracted from the same GTIs, and response files were produced as explained in Section 2.2. We then fitted the resultant spectra in XSPEC with a simple model of an absorbed power law. The best-fitting parameters are $N_{\rm H} = 2.2 \pm 0.3 \times 10^{22}$ cm^{-2} and $\Gamma = 0.38 \pm 0.14$ with a 2–10 keV unabsorbed flux of 6.9×10^{-11} erg cm^{-2} s^{-1} for the low phase, and $N_{\rm H} = 2.19 \pm 0.12 \times 10^{22}$ cm^{-2}, and $\Gamma = 0.56 \pm 0.05$ with a 2–10 keV unabsorbed flux of 1.5×10^{-11} erg cm^{-2} s^{-1} for the high phase. In both cases the reduced χ^2 value is close to 1. The Γ–$N_{\rm H}$ contour plots for both phases are given in Fig. 9. It is clear that the variations between both phases are not due to variations of the absorbing column density. On the contrary, they seem to reflect some changes in the spectral properties of the emitting medium, since there is some increase in

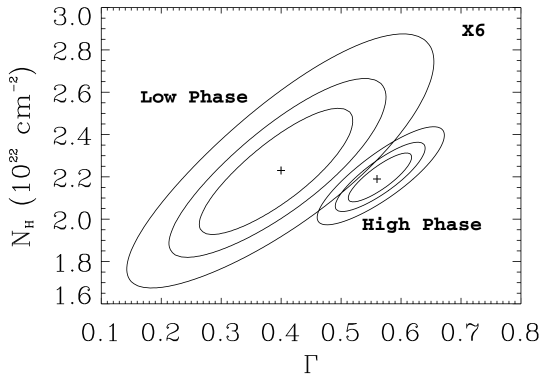

Figure 9. Confidence contour plots of the column density $N_{\rm H}$ versus the photon index Γ for a power-law fit to high and low phases of observation X6. The contours are the 68, 90 and 99 per cent confidence levels.

the photon index. However, at the 3σ level both values are still compatible.

We investigated the energetic dependence of the pulse fraction for the bright state of the source (observation X6) and found that it is more or less stable around 53–55 per cent in the 4–10 keV energy band and increases to ∼63 per cent in the soft 2–4 keV band.

4 OPTICAL COUNTERPART AND THE SOURCE DISTANCE

The accretion-powered X-ray pulsars are usually found within high-mass X-ray binaries (HMXB). The HMXB may be divided mainly into those with main-sequence Be star companions, and those with evolved OB supergiants companions.

In the case of Be/X-ray binaries the hard X-ray emission is caused by accretion of circumstellar material on to the neutron star. The source of accreting material is thought to be concentrated towards the equatorial plane of the rapidly rotating Be stars. Most Be/X-ray binaries are transients, displaying X-ray outburst and long periods of quiescence, when no X-ray flux is detected. A smaller group of Be/X-ray binaries are persistent sources with rather low X-ray luminosity ($<10^{35}$ erg s^{-1}), relatively long (>200 s) pulse periods and a very weak iron line at 6.4 keV (Reig & Roche 1999; Haberl & Pietsch 2004; Negueruela 2004).

The supergiant binaries may be further subdivided into two classes, depending on whether the mass transfer is due to Roche lobe overflow or a capture from the stellar wind. As the typical spin period for the pulsars with the companions filling its Roche lobe is less than 20 s (e.g. Corbet 1986) such a companion seems to be unlikely for 2RXP J130159.6-635806. The wind-fed supergiant binaries have a long spin period (of several hundred seconds), and are pesistent sources with short, irregular outbursts (e.g. Corbet 1986; Bildsten et al. 1997; Negueruela 2004). All the known systems display approximately the same X-ray luminosity $\sim 10^{36}$ erg s^{-1}. Variable X-ray activity of 2RXP J130159.6-635806 indicates that this binary system is unlikely to contain an OB supergiant.

In any of the cases mentioned above we should expect that the optical companion of the X-ray source should be bright in the optical and infrared spectral bands. In order to check this we used the results of DSS and 2MASS surveys. In both catalogues a relatively bright star with magnitudes $B = 17.2$, $R = 13.9$, $J = 8.87$, $H = 7.53$ and $K = 7.01$, is visible in the vicinity of the X-ray source, but its position is just outside the *XMM–Newton* error box (the offset between the positions is ∼4.4 arcsec). Besides this bright star another possible counterpart candidate is found in 2MASS with coordinates (equinox 2000) RA = $13^{\rm h}\,01^{\rm m}\,58\overset{\rm s}{.}7$, Dec. = $-63^\circ\,58'\,09''$ (at ∼1.1 arcsec from the best *XMM–Newton* position) and magnitudes $J = 12.96 \pm 1.33$, $H = 12.05 \pm 0.03$ and $K_s = 11.35 \pm 0.09$. The good agreement between both positions would tend to suggest that this second source is the likely counterpart to 2RXP J130159.6-635806.

To estimate the dereddened magnitude we assume that this counterpart was only absorbed by the Galactic absorption on the line of sight. Using the value of $N_{\rm H} = 1.7 \times 10^{22}$ cm^{-2} we estimate the dereddened magnitudes $J_{\rm der} = 10.73 \pm 1.33$, $H_{\rm der} = 10.72 \pm 0.03$ and $K_{s\,\rm der} = 10.51 \pm 0.09$ (only statistical uncertainties are quoted). If the companion star is a Be main-sequence star with a surface temperature around 10 000 K and a radius around 6–10 $R_\odot$ we can expect to see its infrared brightness J, H, $K \sim 10$–11 if the binary system is at a distance of ∼4–7 kpc. An additional tentative argument in favour of such a source distance is the source location in the direction to the Crux spiral arm tangent, as HMXBs are concentrated towards galactic spiral arms (Grimm, Gilfanov & Sunyaev 2002; Lutovinov et al. 2005b). At such a distance the unabsorbed intrinsic luminosity of 2RXP J130159.6-635806 is about $\sim 5 \times 10^{34}$–10^{35} erg s^{-1}, i.e. compatible with the typical luminosities of the persistent Be/X-ray binaries.

5 CONCLUSIONS

We report the identification by *XMM–Newton* of a new X-ray pulsar with a spin period of ∼700 s in the region of the Crux spiral arm. The source was observed several times in 1993–2004 with *ASCA*, *BeppoSAX* and *XMM–Newton* during the monitoring campaigns of the pulsar PSR B1259-63. The typical flux measured from the source in the 2–10 keV energy band is about (2–3) $\times 10^{-11}$ erg cm^{-2} s^{-1}, but in 2004 January–February an outburst with an increase of intensity of more than five times was observed from the source. During this outburst the source was also detected in the hard X-ray range with the *INTEGRAL* observatory. Strong pulsations of the X-ray flux with a period of ∼700 s were detected. The study of a set of observations has shown that the pulse period changed from ∼735 s in 1994 to ∼704 s in 2004. The average value of the spin-up rate is $\dot{\nu} \simeq 2 \times 10^{-13}$ Hz s^{-1}, that is typical for accretion-powered X-ray pulsars (see, e.g., Bildsten et al. 1997). A long pulsation period indicates that the pulsar probably resides in a binary system with a massive companion. The proposed infrared counterpart to the X-ray source does not contradict this hypothesis. From the brightness of the infrared counterpart measured, a tentative estimate of the distance of the binary system is 4–7 kpc, which could indicate that the HMXB is located close to the Crux spiral arm tangent.

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